Influence of Chaining Pinyon-Juniper on Watershed Values in Utah

Project Report

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in cooperation with
Bureau of Land Management

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Title of Study: Effects of Pinyon-Juniper Conversion on Watershed Values in Utah

Objectives:

A. To determine the water budget of natural stands of pinyon-juniper and adjacent areas which have been cleared and/or seeded.

B. To determine the effects of vegetation conversion on soil physical properties and soil stability.

C. To ecologically evaluate sites before and after as to phenology, composition, and production of vegetation.

D. To evaluate the economics of conversion practices in terms of the watershed values and multiple use relations.

E. To obtain data necessary for determination of hydrologic soil cover complexes on the study sites.

Introductory Comment: This report is concerned with additional data analysis and compilation which has resulted since the project report dated November 15, 1969. As before, the report will provide information to supplement previous reports as well as indicate progress to date.

Infiltrometer Studies: Data analyses are essentially complete on these studies. One paper has been published (J. Range Mgt. 22: 110-114), one paper is soon to be published, and a third paper has been submitted for publication. Manuscripts of the latter two papers are included in the Appendix.

Soil Studies: Soil analyses are nearly complete for characterizing soils beneath each runoff plot. These analyses should be included in the April 1, 1971, project report.

Results from soil moisture studies will also be included in the April 1 project report.

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1. [illegible] of nitrogen [illegible]

2. [illegible] of vegetation communities [illegible]

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Influence of Cryptogams (Lichens and Algae) on Hydrologic Properties of Soils in Southeastern Utah

The soil analysis portion of this project phase has been completed and generalized results are given in the table that follows. Soil samples were taken at depths of 0-1/2 inch, 1/2-1 inch, and 1-2 inches between trees or in the open from lichen stands in several conditions of development or destruction:

1. Virgin stand (completely undisturbed)
2. Well developed stands in control area of fenced study area
3. Intermediately developed stand in control area
4. Pathways and water-ways within control area
5. Debris-in-place chaining
6. Chaining with windrowing

Values given in Table show only trends as they are averages of all three depths sampled. Statistical analyses are yet to be carried out.

Percent organic matter was calculated from organic carbon determined using the sulfuric acid digestion method. Preliminary results show only small differences which may not be significant.

Determination of pH showed the soils of all sites to be slightly alkaline (around pH 7.3) with the soil from the virgin stand slightly more alkaline (7.6).

Differences in soil conductivity among the sites are comparable except for a higher value from the windrowed chaining site. This would indicate a slightly higher salt content in the surface soils.

A determination of the amount of Ca plus Mg present was made and most sites showed about 1.5 me/liter. The virgin lichen site and the windrowed chaining showed higher values of about 2.3 and 3.0 meq/liter respectively.

Table /. Physical and chemical properties of surface soils supporting cryptogam development in southeastern Utah -

Site	Percent Organic Matter	Conductivity (Mmhos/cm) (at 25°C)	pH	Ca plus Mg (meq/1)	Textural Analysis % Sand	% Silt	% Clay	Percent Aggregates 2 mmd
Virgin stand (completely undisturbed)	1.10	.836	7.64	2.28	48.6	43.4	8	4.2
Well developed stand in control area of fenced study area	0.87	.701	7.28	1.40	53.6	40.2	6.2	2.2
Intermediately developed stand in control area	1.10	.842	7.35	1.77	54.0	36.6	9.4	2.8
Pathways and waterways within control area	1.09	.841	7.33	1.35	54.2	35.8	10	2.6
Debris-in-place chaining	1.15	.779	7.27	1.42	56.2	34.4	9.4	2.8
Windrowed chaining	0.97	1.128	7.36	2.97	62.0	27.4	10.6	6.8

- All values are averages representing theee depths of soil sampling

Soil textural analysis showed the soils of the several sites fall in the sandy loam category. All sites were found to be similar in soil texture except perhaps the windrowed chaining site which has more sand than the rest. The same site has a slightly higher percent of water stable aggregates less than 2 mmd. The remainder of the sites showed similar aggregate percentages.

Some soils, when coated with organic residues, show resistence to wetting. A cursory check for non-wettable properties was made at one third, one, and fifteen atmospheres for all sites. There appear to be no non-wettable properties inherent in the soils sampled at any of the sites. However, no samples were taken from beneath litter accumulations under trees.

Work yet to be completed

Infiltrometer runs will be made at each of the several sites and runoff and sediment production will be examined. It has been observed that when water is poured on the surface of the ground, the different crust conditions behave quite differently; those with more crustal cover resist disintegration better than poorly covered areas. This might imply that the mechanical strength of the crust and its ability to break the force of falling water may be involved in the hydrologic role of the crust.

In addition, permeability trials will be run on undisturbed cores.

Runoff Plot Studies: No runoff events occurred at either site during 1969. Data from runoff events during 1970 are currently being analyzed, and will be reported in the April 1 project report.

Tables 2, 3, 4, and 5 show rainfall amounts received at the Blanding and Milford sites during 1969. Since runoff - producing storms were lacking, only data from one recording and one nonrecording gage are shown.

Tables 6, 7, 8, 9, 10, and 11 show rainfall amounts received at the two study sites during 1970. Data for all gages are included. Figure 1 shows general layout of the study area at Blanding. Aerial photos of the Milford site have not been available since the photos are being currently used in Denver for map making purposes.

Vegetation Studies: Tables 12 and 13 give tree, shrub, and ground cover on debris-in-place and windrow runoff plots, respectively, at Blanding during the 1968 season. Vegetation data for the Milford study area for 1968 was included in the April 1, 1969, project report.

Tables 14 and 15 give cover conditions on Blanding and Milford runoff plots for the year 1969. There was quite a change in cover conditions during the year 1967 to 1968.

Cover information for 1969 will be forthcoming in the April 1, 1971, report.

Production data for 1969 and 1970 are given in Tables 16 and 17. The large increase in production at both sites during 1970 over that produced in 1969 is evident. It is of particular interest to note the difference between the rabbit-grazed and rabbits excluded areas at Milford. Particularly hard hit was the chain and windrow area. Figure 2 shows a portion of a fenced 0.11 acre runoff plot in the windrowed area as contrasted to the rabbit-grazed outside area.

Miscellaneous Studies: A small study of patterns of water movement over and through P-J litter was done during 1969. The manuscript showing results of this study is given in the appendix.

Table 2. Precipitation data from 8-inch recording gage at Blanding pinyon-juniper study site, 1969

Date	Total Rainfall (inches)
6-1-69	Start
6-11-69	.05
6-12-69	.05
6-17-69	.05
6-18-69	.25
6-24-69	.15
7-13-69	.63
7-16-69	.10
7-17-69	.07
7-18-69	.39
7-19-69	1.05
7-20-69	.12
7-23-69	.02
7-24-69	.38
7-29-69	No Record
8-11-69	.05
8-12-69	.02
8-14-69	.20
8-15-69	.01
8-16-69	.03
8-17-69	.02
8-18-69	.05
8-20-69	.04
8-24-69	.03
8-25-69	.17
8-26-69	.20
8-27-69	.02
8-29-69	.40
8-30-69	.03
8-31-60	.02
9-1-69	.02
9-3-69	.01
9-4-69	.01
9-6-69	.45
9-17-69	.08
10-1-69	.90
10-9-69	Off

Table 3. Precipitation data from 8-inch non-recording gage at Blanding pinyon-juniper study site, 1969

Date	Total Rainfall (inches)
6-1-69 to 6-29-69	.55
6-29-69 to 7-12-69	0
7-13-69 to 7-28-69	2.77
7-29-69 to 8-9-69	No Record
8-10-69 to 8-22-69	.36
8-23-69 to 9-5-69	.90
9-6-69 to 9-17-69	.59
9-18-69 to 10-9-69	.95

Table 4. Precipitation data from 8-inch recording gage at Milford pinyon-juniper study site, 1969

Date	Total Rainfall (inches)
5-18-69	Start
6-11-69	.10
6-12-69	.20
6-13-69	.05
6-15-69	.02
6-16-69	.35
6-17-69	.40
6-18-69	.05
6-20-69	.02
6-21-69	.03
6-24-69	.15
7-14-69	.30
7-15-69	.05
7-17-69	.17
7-18-69	.05
7-21-69	.04
7-22-69	.13
7-23-69	.17
7-24-69	.03
7-29-69	.25
7-30-69	.02
7-31-69	.35
8-2-69	.28
8-12-69	.02
8-19-69	.07
8-26-69	.03
9-6-69	.04
9-7-69	.10
9-15-69	.73
9-16-69	.20
10-4-69	.03
10-9-69	.12
10-16-69	.35
10-17-69	.15
10-18-69	.16
10-19-69	.40
10-20-69	.03
11-1-69	Stop

Table 5. Precipitation data from 8-inch nonrecording gage at Milford pinyon-juniper study site, 1969.

Date	Total Rainfall (inches)
5-18-69 to 6-24-69	1.49
6-25-69 to 7-10-69	0
7-11-69 to 7-25-69	.87
7-26-69 to 8-8-69	.97
8-9-69 to 8-24-69	.07
8-25-69 to 9-6-69	.07
9-7-69 to 9-22-69	1.13
9-23-69 to 11-1-69	1.32
11-2-69 to 12-15-69	1.26

Table 6. Precipitation data from 8-inch recording gages at Milford study site, 1970.

Date	Total Rainfall (inches)	
	Windrow Area	Debris-in-Place
6-9-70	Start	
6-10-70	0.18	
6-12-70	0.04	Start (0.05)
7-4-70	0.28	0.40
7-5-70	0.04	0.03
7-6-70	0.38	0.37
7-8-70	0.15	No record
7-10-70	0.03	0.03
7-18-70	0.11	0.14
7-20-70	0.12	0.13
7-21-70	0.52	0.53
7-22-70	0.67	0.70
7-23-70	0.05	0.08
7-24-70	0.31	0.28
7-25-70	0.35	0.31
7-26-70	0.28	0.13
7-29-70	0.15	0.08
8-5-70	0.13	No record
8-12-70	0.05	No record
8-13-70	0.47	No record
8-14-70	0.15	No record
8-17-70	0.33	No record
8-18-70	0.39	0.38
8-20-70	0.31	0.31
8-21-70	0.02	0.02
8-26-70	0.03	0.04
8-27-70	0.32	0.30
9-5-70	1.47	1.53
10-24-70	Off (storage gage charged)	

Table 7. Precipitation data from 8-inch nonrecording gages at Milford, debris in place area, 1970.

Date	Total Rainfall (inches)		
	Gage A	Gage B	Gage C
6-10-70 to 6-24-70	0.03	0.03	
6-24-70 to 7-9-70	0.98	1.13	0.98
7-9-70 to 7-23-70	1.64	1.77	1.73
7-23-70 to 8-7-70	1.20	1.35	1.35
8-7-70 to 8-18-70	0.91	1.22	1.17
8-18-70 to 9-7-70	2.59	2.71	2.79
9-7-70 to 9-16-70	0.00	0.00	0.00
9-16-70 to 10-4-70	0.00	0.00	0.00
10-4-70 to 10-24-70	0.00	0.00	0.00

Table 8. Precipitation data from 8-inch nonrecording gages at Milford, windrowed area, 1970.

Date	Total Rainfall (inches)		
	Gage A	Gage B	Gage C
12-16-69 to 3-28-70	3.05*		
3-28-70 to 4-26-70	0.78*		
4-26-70 to 5-23-70	0.54*		
5-23-70 to 6-9-70	0.80*		
6-9-70 to 6-24-70	0.20	(For period 6-12-70 to 6-24-70, gage A read 0.04 inches and gage B, 0.02 inches.)	
6-24-70 to 7-9-70	1.04	1.26	1.00
7-9-70 to 7-23-70	1.59	1.73	1.69
7-23-70 to 8-7-70	1.35	1.42	1.35
8-7-70 to 8-18-70	0.96	0.86	1.13
8-18-70 to 9-7-70	2.71	2.82	2.61
9-7-70 to 9-16-70	0.00	0.00	0.00
9-16-70 to 10-4-70	0.00	0.00	0.00
10-4-70 to 10-24-70	0.00	0.00	0.00

*Single storage gage operated during this period.

Table 9. Precipitation data from 8-inch recording gages at Blanding study site, 1970.

Date	Total Rainfall (inches)	
	Windrow Area	Debris-in-Place
6-14-70	Start	Start
7-6-70	0.07	.07
7-8-70	0.08	.09
7-9-70	0.07	.07
7-10-70	0.09	.07
7-16-70	0.06	.09
7-18-70	0.15	.16
8-1-70	0.00	.06
8-3-70	1.27	1.17
8-4-70	0.81	0.72
8-6-70	0.14	0.17
8-8-70	0.02	0.02
8-16-70	1.00	0.76
8-19-70	0.75	0.69
8-20-70	0.28	0.32
9-4-70	0.10	0.10
9-5-70	0.35	0.35
9-12-70	0.45	0.50
10-7-70	0.06	0.07
10-8-70	0.05	0.05
10-22-70	0.40	0.44
10-26-70	Off (storage gages charged)	

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Table 10. Precipitation data from 8-inch nonrecording gages at Blanding, debris-in-place area, 1970.

Date	Total Rainfall	
	Gage A	Gage B
6-14-70 to 6-28-70	0.00	0.00
6-28-70 to 7-12-70	0.30	0.29
7-12-70 to 7-26-70	0.20	0.15
7-26-70 to 8-9-70	2.08	1.70
8-9-70 to 8-22-70	1.94	1.92
8-22-70 to 9-2-70	0.01	0.01
9-2-70 to 9-14-70	0.93	0.94
9-14-70 to 9-29-70	0.00	0.00
9-29-70 to 10-26-70	0.58	0.56

Table //. Precipitation data from 8-inch nonrecording gages at Blanding, windrow area, 1970.

Date	Total Rainfall (inches)	
	Gage A	Gage B
6-14-70 to 6-28-70	0.00	0.00
6-28-70 to 7-12-70	0.29	0.30
7-12-70 to 7-26-70	0.27	0.12
7-26-70 to 8-9-70	2.28	2.05
8-9-70 to 8-22-70	2.10	1.95
8-22-70 to 9-2-70	0.03	0.02
9-2-70 to 9-14-70	0.92	0.92
9-14-70 to 9-29-70	0.00	0.00
9-29-70 to 10-26-70	0.52	0.50

Figure /. General layout of study area near Blanding, Utah. Circled numbers indicate location of raingages. Small crosses indicate approximate locations of 0.11 acre runoff plots. Area A is a control, area B chained and windrowed, area C a control, and area D chained with debris in place. Scale 1" = 1480 ft.

Table 12. Tree, shrub, and ground cover (percent) on runoff plots at the Fry Canyon (Blanding) study site, September 1, 1968. ~~(Windrowed plot data in April 1, 1969, Progress Report)~~.

Plot	Transect No. 1/	Trees	Percent Cover		
			Shrub	Ground 2/	
Debris in Place Check #1	19 ft.	Pied 37.45	0.00	L	63.70
		Juos 15.25		BG	36.30
	33 ft.	Pied 10.23		BG	64.86
		Juos 54.63	0.00	L	35.14
	74 ft.	Juos 8.44	0.00	BG	85.80
				L	14.20
	Mean ($\bar{x}$)	Pied 15.89	0.00	BG	62.32
		Juos 26.11		L	37.68
Debris in Place Check #2	19 ft.	Pied 5.40	0.00	BG	66.40
		Juos 19.80		L	33.60
	33 ft.	Pied 9.41	0.00	BG	54.70
		Juos 30.39		L	45.30
	74 ft.	Pied 13.34	0.00	BG	45.07
		Juos 43.32		L	54.93
	Mean (x)	Pied 9.38	0.00	BG	55.39
		Juos 31.17		L	44.61
Debris in Place Check #3	19 ft.	Juos 52.38	0.00	BG	58.48
				L	41.52
	33 ft.	Pied 11.62	0.00	BG	59.24
		Juos 33.90		L	40.76
	74 ft.	Juos 16.67	0.00	BG	82.55
				L	17.45
	Mean ($\bar{x}$)	Pied 3.54	0.00	BG	66.76
		Juos 34.31		L	33.24

Table 12. Continued

Plot	Transect No. 1/	Trees	Percent Cover Shrub	Ground 2/	
Debris in Place Check #4	19 ft.	Pied 15.52 Juos 24.14	0.00	BG L	35.25 64.75
	33 ft.	Pied 8.76 Juos 42.48	0.00	BG L	51.24 48.76
	74 ft.	Juos 29.79	0.00	BG L	49.53 50.47
	Mean ($\bar{x}$)	Pied 8.09 Juos 32.14	0.00	BG L	45.34 54.66
Debris in Place Check #5	19 ft.	Juos 80.42	0.00	BG L	18.44 81.56
	33 ft.	Pied 14.86 Juos 30.86	0.00	BG L	53.72 46.28
	74 ft.	Pied 2.85 Juos 31.69	0.00	BG L	42.70 57.30
	Mean ($\bar{x}$)	Pied 5.90 Juos 47.66	0.00	BG L	38.29 61.71
Debris in Place #1	19 ft.	0.00	0.00	BG L Annual	49.71 50.01 .28
	33 ft.	0.00	0.00	BG L Annual Agcr	56.26 43.17 .38 .19
	74 ft.	0.00	0.00	BG L	19.81 80.19
	Mean ($\bar{x}$)	0.00	0.00	BG L Annual Agcr	42.06 57.79 0.09 0.06

Table 12. Continued

Plot	Transect No. 1/	Trees	Percent Cover Shrubs	Ground 2/	
Debris in Place #2	19 ft.	0.00	0.00	BG	72.09
				L	27.33
				Annual	.19
				Agcr	.39
	33 ft.	0.00	0.00	BG	43.11
				L	56.51
				Annual	.19
				Agcr	.19
	74 ft.	0.00	0.00	BG	40.27
				L	59.53
				Annual	.20
	Mean ($\bar{x}$)	0.00	0.00	BG	51.83
				L	47.79
				Annual	0.19
				Agcr	0.19
Debris in Place #3	19 ft.	0.00	0.00	BG	62.65
				L	36.78
				Agcr	.38
				Annual	.19
	33 ft.	0.00	0.00	BG	18.50
				L	80.93
				Agcr	.38
				Annual	.19
	74 ft.	0.00	0.00	BG	43.71
				L	55.53
				Agcr	.76
	Mean ($\bar{x}$)	0.00	0.00	BG	41.61
				L	57.75
				Agcr	0.51
				Annual	0.13

Table 12. Contiued

Plot	Transect No. 1/	Trees	Percent Cover Shrub	Percent Cover Ground 2/	
Debris in Place #4	19 ft.	Pied .19	0.00	BG	84.14
				L	16.48
				Opuntia sp.	.38
	33 ft.	0.00	0.00	BG	71.98
				L	27.45
				Agcr	.57
	74 ft.	0.00	0.00	BG	20.58
				L	79.42
	Mean (x̄)	Pied 0.06	0.00	BG	58.56
				L	41.12
				Agcr	0.19
				Opuntia spp	0.13
Debris in Place #5	19 ft.	0.00	0.00	BG	62.91
				L	37.09
	33 ft.	0.00	0.00	BG	42.18
				L	57.25
				Agcr	.19
				Annual	.38
	74 ft.	0.00	0.00	BG	58.48
				L	39.05
				Annual	1.52
				Agcr	.95
	Mean (x̄)	0.00	0.00	BG	54.52
				L	44.46
				Agcr	0.38
				Annual	0.64

1/ Line transects across runoff plots at indicated distances measured from top of plot.

2/ BG category includes cryptogam cover on soil surface.
BG = Bare Ground
L = Litter
Pied = *Pinus edulis*
Juos = *Juniperus osteosperma*
Agcr = *Agropyron cristatun*

Table 13 Tree, shrub and ground cover (percent) on windrow runoff plots of the Blanding study site, September, 1968.

Plot	Transect Number[1/]	Percent Cover Tree	Shrub	Ground[2/]	
Windrow #1	19 ft.	0.00	0.00	P	0.00
				Agcr	0.75
				L	8.05
				Annual (A)	0.75
				Unknown Z	0.94
				BG	89.51
	33 ft.	0.00	0.00	Agcr	0.15
				L	2.96
				Annual (A)	0.02
				Unknown Z	0.17
				BG	96.70
	74 ft.	0.00	3.42	Agcr	0.36
				L	3.96
				BG	95.68
$\overline{X}$		0.00	1.11	Unknown Z	0.37
				P	0.00
				Agcr	0.42
				L	4.99
				Annual (A)	0.26
				BG	93.96
Windrow #2	19 ft.	0.00	0.00	Agcr	0.13
				L	5.32
				Annual (A)	0.04
				BG	94.51
	33 ft.	0.00	0.00	Agcr	2.84
				L	1.52
				Annual (A)	0.38
				BG	95.26
	74 ft.	0.00	0.00	Agcr	1.84
				L	2.40
				Annual (A)	0.55
				Unknown Z	1.11
				BG	95.10
$\overline{X}$		0.00	0.00	Agcr	1.60
				L	3.08
				Annual (A)	3.23
				Unknown Z	0.37
				BG	94.99

Table 13 continued

Plot	Transect Number[1]	Percent Cover: Tree	Shrub	Ground[2]	
Windrow #3	19 ft.	0.00	0.00	Agcr	0.19
				L	11.67
				BG	88.14
	33 ft.	0.00	0.00	Agcr	1.86
				L	6.36
				Annual (A)	0.37
				BG	91.41
	74 ft.	0.00	0.00	Agcr	1.26
				L	11.17
				Annual (B)	0.18
				BG	87.39
$\overline{X}$		0.00	0.00	Agcr	1.10
				L	9.73
				Annual (A)	0.12
				Annual (B)	0.06
				BG	89.01
Windrow #4	19 ft.	0.00	0.00	Agcr	0.38
				L	2.67
				Annual (A)	0.19
				BG	96.76
	33 ft.	0.00	0.00	Agcr	0.95
				L	10.82
				Annual (A)	0.19
				BG	88.04
	74 ft.	0.00	0.00	Agcr	0.93
				L	4.46
				Annual (A)	0.37
				Eriogonum spp.	1.11
				BG	93.13
$\overline{X}$		0.00	0.00	Agcr	10.75
				L	5.98
				Annual (A)	0.25
				Eriogonum spp.	0.37
				BG	92.64

Table 13 continued

Plot	Transect Number[1/]	Tree	Shrub	Percent Cover	Ground[2/]
Windrow #5	19 ft.	0.00	0.00	Agcr	0.96
				L	7.11
				BG	91.93
	33 ft.	0.00	0.00	Agcr	0.97
				L	1.55
				BG	97.48
	74 ft.	0.00	0.00	Agcr	0.39
				L	1.93
				BG	97.68
$\overline{X}$		0.00	0.00	Agcr	0.77
				L	3.53
				BG	95.70
Windrow Check #1	19 ft.	Juos 21.21	0.00	L	58.33
		Pied 29.55		BG	41.67
		Juos 16.42	6.90	L	41.79
	33 ft.	Pied 15.49		BG	58.21
		Juos 27.19	0.00	L	61.26
	74 ft.	Pied 33.89		BG	38.74
$\overline{X}$		Juos 21.61	2.30	L	53.79
		Pied 33.89		BG	46.20
Windrow Check #2	19 ft.	Juos 30.04	0.00	L	29.84
		Pied 8.30		BG	70.16
	33 ft.	Juos 1.19	0.00	L	6.75
				BG	93.25
	74 ft.	Juos 6.84	0.00	L	14.89
				BG	85.11
$\overline{X}$		Juos 12.69	0.00	L	17.16
		Pied 2.60		BG	82.84
Windrow Check #3	19 ft.	Pied 22.88	0.00	L	34.62
				BG	65.38
	33 ft.	Juos 6.77	0.00	L	25.53
		Pied 12.77		Annual	0.19
				BG	74.28
	74 ft.	Juos 22.90	0.00	L	56.36
				BG	43.64
$\overline{X}$		Juos 9.89	0.00	L	38.84
		Pied 11.88		BG	61.10
				Annual	.06

Table 13 continued

Plot	Transect Number 1/	Percent Cover Tree	Shrub		Ground 2/
Windrow Check #4	19 ft.	Juos 24.12	0.00	L BG	41.18 58.82
	33 ft.	Juos 13.23 Pied 5.45	Artr 2.33	L BG	55.64 44.36
	74 ft.	Juos 16.54 Pied 3.31	Artr 12.06	L BG	38.72 61.28
$\overline{X}$		Juos 17.96 Pied 2.92	Artr 4.80	L BG	45.18 54.82
Windrow Check #5	19 ft.	Juos 15.90	0.00	L BG	29.31 70.69
	33 ft.	Juos 14.53 Pied 18.55	0.00	L BG	41.68 58.32
	74 ft.	Juos 3.04 Pied 18.60	0.00	L BG	30.74 69.26
$\overline{X}$		Juos 11.16 Pied 12.38	0.00	L BG	33.91 66.09

1/ Line transects across runoff plots at indicated distances measured from top of plot.

2/ P = pavement
L = litter
R = rock
BG = bare ground

Agcr = *Agropyron cristatum*
Artr = *Artemisia tridentata*

[illegible]

Table 14. Tree, shrub and ground cover (percent) on runoff plots at the Fry Canyon (Blanding) site, September 1, 1969.

Plot	Transect No. 1/	Percent Cover: Trees	Percent Cover: Shrubs	Percent Cover: Ground 2/	
Windrow #1	19 ft.	0.00	0.00	BG	36.77
				L	39.59
				Agcr	23.44
				Sphaeralcea spp.	.20
	33 ft.	0.00	0.00	BG	46.09
				L	17.91
				Agcr	36.00
	74 ft.	0.00	0.00	BG	61.78
				L	14.49
				Agcr	15.04
				Artr & Agcr	3.08
				Arta	4.35
				Eriogonum spp.	1.27
	Mean ($\bar{x}$)	0.00	0.00	BG	48.20
				L	24.00
				Agcr	24.83
				Artr & Agcr	1.03
				Artr	1.45
				Sphaeralcea spp.	0.07
				Eriogonum spp.	0.42
Windrow #2	19 ft.	0.00	0.00	BG	53.90
				L	17.33
				Agcr	26.48
				Sphaeralcea spp.	2.29
	33 ft.	0.00	0.00	BG	47.35
				L	20.64
				Agcr	30.12
				Sphaeralcea spp.	1.89
	74 ft.	0.00	0.00	BG	70.27
				L	6.50
				Agcr	21.19
				Sphaeralcea spp.	2.04

Table 14. Continued

Plot	Transcect No. 1/	Trees	Percent Cover Shrubs	Ground 2/	
	Mean (x)	0.00	0.00	BG	57.18
				L	14.82
				Agcr	25.93
				Sphaeralcea spp.	2.07
Windrow #3	19.ft	0.00	0.00	BG	44.05
				L	22.87
				Agcr	30.62
				Artr	2.46
	33 ft.	0.00	0.00	BG	60.42
				L	14.01
				Agcr	25.57
	74 ft.	0.00	0.00	BG	19.31
				L	48.92
				Agcr	31.77
	Mean ($\bar{x}$)	0.00	0.00	BG	41.26
				L	28.60
				Agcr	29.32
				Artr	0.82
Windrow #4	19 ft.	0.00	0.00	BG	58.02
				L	18.89
				Agcr	22.33
				Sphaeralcea spp.	.38
				Saka	.38
	33 ft.	0.00	0.00	BG	54.84
				L	15.37
				Agcr	29.41
				Saka	.38
	74 ft.	0.00	0.00	BG	44.49
				L	33.21
				Agcr	22.20
	Mean ($\bar{x}$)	0.00	0.00	BG	52.48
				L	22.49
				Agcr	24.65
				Sphaeralcea spp.	0.13
				Saka	0.25

Table 14. Continued

Plot	Transect No. 1/	Trees	Shrubs	Ground 2/	
		Percent Cover			
Windrow #5	19 ft.	0.00	0.00	BG	17.34
				L	40.27
				Agcr	37.19
				Aster spp.	5.20
	33 ft.	0.00	0.00	BG	70.29
				L	9.32
				Agcr	19.81
				Unknown	.58
	74 ft.	0.00	0.00	BG	49.42
				L	25.00
				Agcr	25.58
	Mean ($\bar{x}$)	0.00	0.00	BG	45.69
				L	24.86
				Agcr	27.53
				Aster spp.	1.73
				Unknown	0.19
Debris in Place #1	19 ft.	0.00	0.00	BG	29.86
				L	67.89
				Agcr	2.25
	33 ft.	0.00	0.00	BG	19.81
				L	55.58
				Agcr	19.04
				Unknown perennial	5.00
				Sphaeralcea spp.	.57
	74 ft.	0.00	0.00	BG	14.15
				L	83.36
				Agcr	2.49
	Mean ($\bar{x}$)	0.00	0.00	BG	21.28
				L	68.94
				Agcr	7.93
				Sphaeralcea spp.	0.19
				Unknown perennial	1.66

Table 14. Continued

Plot	Transect No. 1/	Trees	Percent Cover Shrubs	Ground 2/	
Debris in Place #2	19 ft.	0.00	0.00	BG	18.74
				L	51.94
				Agcr	24.51
				Pied	.19
				Unknown perennial	1.56
				Saka	2.87
				Crvi	.19
	33 ft.	0.00	0.00	BG	.59
				L	87.89
				Agcr	7.22
				Eriogonum spp.	4.30
	74 ft.	0.00	0.00	BG	7.00
				L	78.40
				Agcr	7.78
				Aster spp.	6.82
	Mean ($\bar{x}$)	0.00	0.00	BG	8.79
				L	72.74
				Agcr	13.17
				Pied	0.06
				Saka	0.96
				Eriogonum spp.	1.43
				Crvi	0.06
				Aster spp.	2.27
				Unknown perennial	0.52
Debris in Place #3	19 ft.	0.00	0.00	BG	39.35
				L	40.50
				Agcr	10.55
				Saka	9.60
	33 ft.	0.00	0.00	BG	3.08
				L	86.32
				Agcr	10.60
	74 ft.	0.00	0.00	BG	15.32
				L	64.76
				Agcr	5.17
				Saka	14.75

Table 14. Continued

Plot	Transect No. 1/	Trees	Percent Cover Shrubs	Ground 2/	
	Mean ($\bar{x}$)	0.00	0.00	BG q	19.25
				L	63.86
				Agcr	8.77
				Saka	8.12
Debris in Place #4	19 ft.	0.00	0.00	BG	13.79
				L	60.54
				Agcr	13.03
				Saka	12.64
	33 ft.	0.00	0.00	L	72.41
				Agcr	19.54
				Saka	3.45
				Sphaeralcea spp.	4.60
	74 ft.	0.00	0.00	BG	1.91
				L	90.77
				Agcr	4.05
				Sphaeralcea spp.	3.27
	Mean ($\bar{x}$)	0.00	0.00	BG	5.24
				L	74.57
				Agcr	12.21
				Sphaeralcea spp.	2.62
				Saka	5.36
Debris in Place #5	19 ft.	0.00	0.00	BG	16.76
				L	77.46
				Agcr	5.78
	33 ft.	0.00	0.00	BG	19.70
				L	68.18
				Agcr	10.80
				Unknown perennial	1.32
	74 ft.	0.00	0.00	BG	20.42
				L	56.30
				Agcr	15.74
				Aster spp.	6.11
				Astragalus spp.	1.43

[illegible]

Table 14. Continued

Plot	Transect No. 1/	Trees	Percent Cover Shrubs	Ground 2/	
	Mean ($\bar{x}$)	0.00	0.00	BG	18.96
				L	67.31
				Agcr	10.77
				Aster spp.	2.04
				Astragalus spp.	0.48
				Unknown perennial	0.44

1/ Line transects across runoff plots at indicated distances measured from top of plot.

2/ BG = Bare Ground
L + Litter
Agcr = _Agropyron cristatum_
Artr = _Artemisia tridemtata_
Saka = _Salsola kali_

Table 15. Tree, shrub, and ground cover (percent) on runoff plots at Milford study site, September 1, 1969.

Plot	Transect Number 1/	Percent Cover 2/ Trees	Shrubs	Ground	
Debris in Place #1	19 ft.	0.00	Artr 9.73	BG	1.70
				L	50.14
				P	38.46
				Agcr	1.13
				Phho	.57
				Sphaeralcea spp.	3.86
				Eriogonum spp.	.84
				Sihi	1.89
				Lupine spp.	1.41
	33 ft.	0.00	Artr 1.20		
			Arno .55	BG	16.07
				L	19.41
				P	55.61
				Agcr	3.04
				Phho	1.40
				Eriogonum spp.	1.01
				Sphaeralcea spp.	2.34
				Unknowns	1.12
	74 ft.	0.00	0.00	BG	2.17
				L	31.51
				P	46.54
				Agcr	15.30
				Phho	1.28
				Sphaeralcea spp.	8.20
	$\bar{x}$	0.00	Artr	BG	4.98
			Arno	L	33.69
				P	46.87
				Agcr	6.49
				Phho	1.08
				Eriogonum spp.	0.62
				Sphaeralcea spp.	4.80
				Sihi	0.63
				Lupine spp.	0.47
				Unknowns	0.37

Table 15. Continued

Plot	Transect Number 1/	Percent Cover 2/ Trees	Shrubs	Ground	
Debris in Place #2	19 ft.	0.00	Arno 1.23	BG	0.00
			Artr 4.31	L	36.65
				P	56.36
				Agcr	1.23
				Phho	1.23
				Chvi	4.31
				Sphaeralcea spp.	.22
	33 ft.	0.00	Arno 0.62	BG	10.50
				L	18.88
				P	58.59
				Agcr	1.66
				Chvi	2.91
				Sphaeralcea spp.	1.45
				Eriogonum spp.	4.77
				Phho	1.24
	74 ft.	0.00	Arno 0.22	BG	6.48
				L	36.56
				P	43.29
				Sphaeralcea spp.	.66
				Chvi	8.82
				Unknowns	1.11
				Lupine spp.	.22
	$\bar{x}$	0.00	Artr	BG	5.69
			Arno	L	30.70
				P	52.75
				Agcr	1.92
				Sphaeralcea spp.	0.74
				Chvi	5.35
				Eriogonum spp.	1.59
				Phho	0.82
				Lupine spp.	0.07
				Unknowns	0.37
Debris in Place #3	19 ft.	0.00	0.00	BG	1.67
				L	73.15
				P	21.30
				Agcr	.74
				Chvi	1.48
				Lupine spp.	1.48
				Sihi	.18

Table 15. Continued

Plot	Transect Number 1/	Percent Cover 2/ Trees	Shrubs	Ground	
	33 ft.	0.00	Arno 4.30	BG	7.83
				L	71.86
				P	13.85
				Agcr	2.69
				Chvi	1.08
				Penstemon spp.	2.69
	74 ft.	0.00	Arno 0.49	BG	3.10
				L	49.67
				P	41.50
				Agcr	2.39
				Chvi	1.96
				Sphaeralcea spp.	.82
	$\bar{x}$			BG	4.40
				L	64.89
				P	25.55
				Agcr	1.94
				Lupine spp.	0.49
				Sihi	0.06
				Penstemon spp.	0.89
				Sphaeralcea spp.	0.27
				Chvi	1.51
Debris in Place #4	19 ft.	0.00	Arno 2.28	BG	.76
				L	66.10
				P	23.14
				Agcr	1.90
				Chvi	5.33
				Sphaeralcea spp.	2.48
				Sihi	.29
	33 ft.	0.00	Arno 9.44	BG	5.92
				L	35.92
				P	52.40
				Agcr	1.13
				Chvi	2.41
				Sphaeralcea spp.	2.22
	74 ft.	0.00	Arno 4.92	BG	11.48
				L	10.75
				P	62.11
				Agcr	.91
				Phho	.36
				Sphaeralcea spp.	10.02
				Lupine spp.	4.01
				Sihi	.36

Table 15. Continued

Plot	Transect Number 1/	Percent Cover 2/ Trees	Shrubs	Ground	
	$\bar{x}$	0.00	Arno	BG	6.05
				L	37.59
				P	45.88
				Agcr	1.31
				Phho	0.12
				Sphaeralcea spp.	4.91
				Lupine spp.	1.34
				Sihi	0.22
				Chvi	2.58
Debris in Place #5	19 ft.	Pied 7.13	Artr 1.54	BG	6.63
			Arno 2.89	L	43.35
				P	33.29
				Agcr	2.89
				Lupine spp.	7.13
				Unknowns	1.70
				Chvi	5.01
	33 ft.	0.00	Artr 2.11	BG	0.00
				L	33.63
				P	49.90
				Agcr	4.79
				Sihi	.38
				Lupine spp.	3.26
				Unknowns	8.04
	74 ft.	Juos 0.77	Artr 0.96	BG	3.18
			Arno 0.77	L	28.90
				P	54.62
				Agcr	6.55
				Chvi	5.21
				Eriogonum spp.	.96
				Phho	.58
	$\bar{x}$	Juos	Artr	BG	2.89
		Pied	Arno	L	35.67
				P	45.94
				Agcr	4.74
				Chvi	3.41
				Eriogonum spp.	0.32
				Phho	0.19
				Sihi	0.13
				Lupine spp.	3.46
				Unknowns	3.25

Table 15. Continued

Plot	Transect Number	Percent Cover: Tree	Shrub	Ground	
Windrow #1	19 ft.	0.00	0.00	BG	61.63
				L	3.06
				P	12.50
				Agcr	22.81
	34 ft.	0.00	Arno 2.85	BG	6.85
				L	20.24
				P	49.81
				Agcr	20.72
				Unknowns	1.14
				Sphaeralcea spp.	1.14
	74 ft.	0.00	Arno 0.95	BG	51.83
				L	15.72
				P	22.98
				Agcr	9.47
	x			BG	40.13
				L	13.01
				P	28.43
				Agcr	17.67
				Sphaeralcea spp.	0.38
				Unknowns	0.38
Windrow #2	19 ft.	0.00	0.00	BG	67.00
				L	4.60
				Agcr	14.40
				Eriogonum spp.	11.20
				Lupine spp.	2.60
				Phho	.20
	34 ft.	0.00	0.00	BG	59.30
				L	22.31
				Agcr	12.60
				Eriogonum spp.	4.96
				Phho	.83
	74 ft.	0.00	0.00	BG	53.64
				L	11.36
				Agcr	23.41
				Eriogonum spp.	10.23
				Sphaeralcea spp.	1.14
				Chvi	.22

Table 15. Continued

Plot	Transect Number	Percent Cover Tree	Shrub	Ground	
	$\bar{x}$			BG	59.98
				L	12.76
				Agcr	16.80
				Eriogonum spp.	8.80
				Sphaeralcea spp.	0.38
				Chvi	0.07
				Phho	0.34
				Lupine spp.	0.87
Windrow #3	19 ft.	0.00	0.00	BG	90.76
				Agcr	7.58
				Penstemon spp.	1.66
	33 ft.	0.00	0.00	BG	70.85
				L	10.62
				Agcr	17.76
				P	.77
	74 ft.	0.00	0.00	BG	68.89
				L	17.37
				Agcr	5.72
				Penstemon spp.	8.02
	$\bar{x}$			BG	76.83
				L	9.33
				P	0.26
				Agcr	10.35
				Penstemon spp.	3.23
Windrow #4	19 ft.	0.00	0.00	BG	37.19
				L	25.05
				Agcr	18.11
				Lupine spp.	15.80
				Unknowns	.19
				Eriogonum spp.	3.66
	33 ft.	0.00	0.00	BG	48.74
				L	19.93
				Agcr	24.95
				Lupine	6.38

Table 15. Continued

Plot	Transect Number	Percent Cover Tree	Shrub	Ground	
	74 ft.	0.00	0.00	BG	73.66
				L	.84
				Agcr	9.92
				Lupine spp.	15.58
	$\bar{x}$			BG	53.20
				L	15.27
				Agcr	17.66
				Lupine spp.	12.59
				Eriogonum spp.	1.22
				Unknowns	0.06
Windrow #5	19 ft.	0.00	0.00	BG	79.19
				L	5.01
				Agcr	9.83
				Eriogonum spp.	5.97
	33 ft.	0.00	0.00	BG	89.66
				L	2.30
				Agcr	8.04
	74 ft.	0.00	0.00	BG	82.48
				Agcr	17.52
	$\bar{x}$			BG	83.77
				L	2.44
				Agcr	11.80
				Eriogonum spp.	1.99

1/ Line transects across runoff plots at indicated distances measured from top of plot.

2/ BG = bare ground
P = pavement
L = litter
R = rock

Agcr = Agropyron cristatum
Phho = Phlox hoodii
Sihi = Sitanion hystrix
Chvi = Chrysothamnus

Table 16. Mean oven-dry yields (lbs./acre) for various treatments at each study site. Clipping data taken during September, 1969.

Site	Treatment		
	Control	Chain and Windrow	Chain, debris in place
	- - - - - - - - - - lbs/acre, oven dry - - - - - - - - -		
Blanding	2.6 (forb) 2.6 (sagebrush) 5.2	370.2 (grass) 14.4 (forb) 384.6	160.6 (grass) 35.3 (forb) 195.9
Milford	4.0 (grass) 23.5 (forb) 47.1 (sagebrush) 74.6	130.4 (grass) 12.2 (forb) 2.9 (sagebrush) 145.5	41.5 (grass) 110.2 (forb) 85.4 (sagebrush) 237.1

Table 17. Mean oven-dry yields (lbs./acre) for various treatments at each study site. Clipping data taken during September, 1970.

Site	Treatment		
	Control	Chain and Windrow	Chain, Debris in Place
Blanding	4.8 (forb)	533.0 (grass) 10.6 (forb) 543.6	404.2 (grass) 87.9 (forb) 492.1
Milford ------------------------ Rabbit Grazed			
	1.7 (grass 14.0 (forb) 41.1 (sagebrush) 56.8	147.2 (grass) 30.2 (forb) 0.4 (sagebrush) 177.8	78.2 (grass) 334.4 (forb) 126.5 (sagebrush) 539.1
Milford ------------------------ Rabbits Excluded			
	No rabbit-proff fencing in control area.	493.7 (grass) 62.7 (forb) 2.3 (sagebrush) 558.7	165.6 (grass) 498.1 (forb) 125.6 (sagebrush) 789.3

Figure 2. Upper part of 0.11 acre runoff plot and adjacent area showing influence of rabbit grazing outside rabbit-proof fencing.

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APPENDIX

Infiltration and Erosion Studies on Pinyon-Juniper Conversion Sites in Southern Utah [1/]

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Highlight

Infiltration and sediment data from small-plot studies (325 infiltrometer plots) utilizing high intensity simulated rainfall indicate that areas cleared of pinyon-juniper trees and seeded to grass in southern Utah generally show no consistent decrease or increase in sediment yields or infiltration rates at a given point. Of 14 sites studied, four indicated decreased infiltration rates and two indicated increased infiltration rates during one or more time intervals at specific points on the treated areas; one site had significantly higher sediment yields from points on the treated areas.

These results nearly parallel those obtained during similar studies of 14 pinyon-juniper sites in central Utah.

Introduction

Millions of acres of pinyon-juniper lands are located throughout the western United States. Within the past 20 years, numerous large-scale pinyon-juniper conversion programs have been initiated. These programs have created a demand for increased knowledge concerning range and watershed values as influenced by vegetation manipulations in this type.

The authors, in a recently completed infiltrometer study of 14 chained pinyon-juniper sites in central Utah, have shown that conversion of pinyon-juniper to grassland (regardless of length of time since treatment) does not necessarily increase or decrease infiltration rates or always reduce sediment yields from a given point on treated areas (Williams, Gifford, and Coltharp, 1969).

In another study, Gifford and Tew (1969) have found increased permeabilities of surface soils from a chained and windrowed site in southwestern Utah 6 months following treatment. Soils from another site in southeastern Utah (same study) showed a similar trend, although it was statistically significant. Mechanical disturbance associated with double chaining with debris in place did not significantly increase surface soil permeabilities at either site.

Little change in surface runoff and soil moisture patterns has been found following clearing of pinyon-juniper in Arizona (Skau, 1964; Brown, 1965; Collings and Myrick, 1966).

The objective of this project was to study infiltration rates and sediment production at given points on converted and nearby untreated pinyon-juniper sites in southern Utah.

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[illegible] throughout [illegible]

[illegible] conducted [illegible]

[illegible] concerning [illegible]

[illegible]

[illegible] completed [illegible]

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Methods

A Rocky Mountain infiltrometer (Dortignac, 1951) was utilized to simulate high intensity (3 in./hr or greater) rainfall on plots approximately 2.5-$ft.^2$ in area. Fourteen treated and nearby untreated pinyon-juniper sites near Blanding and Milford, Utah were sampled with 325 infiltrometer plots during the summer of 1968. Tables 1 and 2 give a brief description of each site.

All plots were pre-wet a minimum of 2 to 3 hours before infiltrometer runs began. Runoff was measured at selected time intervals during each infiltrometer run. Simulated rainfall was applied to each plot until a constant runoff rate was reached (generally 25 minutes were sufficient).

Sediment was measured by collecting total runoff plus sediment from each plot, mixing thoroughly, and finally obtaining a 1-quart sample. The water was then evaporated off, sediment oven-dried, and sample weights converted to tons per acre.

Soils in the study sites were derived from colluvium, alluvium, residium, and eolian of mainly sedimentary and volcanic rocks (Milford area) and sandstones and shales (Blanding area).

RESULTS AND DISCUSSION

Pinyon-juniper sites near Blanding, Utah

Table 3 shows mean infiltration rates (in./hr.) during specified time intervals and Figure 1 denotes relative differences in sediment production from treated and nearby untreated conditions on six pinyon-juniper sites studied near Blanding, Utah. As noted from Table 1, age

of treatment varied from 1 to 8 years.

U.S.U. (Utah State University) study site. No significant differences in infiltration rates are indicated between treated and untreated conditions during any time interval on the area which had been double chained with debris left in place (item 1, Table 3). However, on the area with debris windrowed, the untreated area showed significantly higher infiltration rates during the time interval 8 to 18 minutes following start of simulated rainfall. There were no significant differences between treated and untreated areas with regard to sediment production.

Area 149, Brush Basin, Peters Point #1, and Peters Point #2. No significant differences between treated and untreated conditions are indicated for either infiltration rates (Table 3) or sediment yields (Figure 1).

Alkali Ridge. At the Alkali Ridge site, the following four exclosures were located within the treated area: (1) everything excluded, (2) rabbits only, (3) deer only, and (4) deer and rabbits only. As noted in Table 3, infiltration rates were significantly greater after approximately 6 minutes of simulated rainfall in the deer-only exclosure and on the treated area (outside exclosures) after 8 minutes. Similarly, in the exclosure excluding everything, a significantly higher infiltration rate was observed during the 8 to 23-minute interval. A significantly higher infiltration rate was indicated for the deer-and-rabbit-only exclosure during the time interval 18 to 23 minutes. No significant infiltration rate differences were noted between treated and untreated conditions as related to the rabbits-only exclosure, though the trend was the same as noted above.

As noted in Figure 1, sediment yields are significantly greater from untreated conditions than from the deer-and-rabbits-only enclosure and the everything-excluded exclosure. Differences were not significant between the other treated vs. untreated conditions though the untreated conditions appeared to yield more sediment in each case.

Pinyon-juniper sites near Milford, Utah

Table 4 shows mean infiltration rates during specified time intervals and Figure 2 denoted relative differences in sediment production from treated and untreated conditions on eight sites near Milford, Utah. As noted from Table 2, age of treatment varied from 1 to 8 years.

Arrowhead Mine and Indian Peaks #1,2,3, and 4. As noted in Table 4 the infiltration rate during the 3 to 4 minute time interval in Indian Peaks #1 site was significantly greater on the untreated area. No significant differences in infiltration rates between treated and untreated conditions were demonstrated for any other time intervals on Indian Peaks numbers 1,2,3 and 4, or Arrowhead Mine. Also, as noted in Figure 2, there were no significant differences in sediment production between treated and untreated conditions on any of the above areas.

U.S.U. study site. No significant differences in infiltration rates are shown (Table 4) between the area which had been double chained with debris left in place and the untreated area. The area with windrowed debris had a significantly lower infiltration rate than the untreated area during the time interval 13 to 28 minutes following start of simulated rainfall. The probably resulted because vegetative cover was lacking on the newly windrowed area.

Significantly more sediment was moved from the windrowed area than

[illegible] Figure 1, sediment yields [illegible] from the [illegible] [illegible] and untreated [illegible]

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Table 1 shows [illegible] time intervals. Table 2 denotes relative differences in [illegible] production from [illegible] and untreated [illegible] eight [illegible] varied from 1 to 8 years.

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from untreated areas. Sediment yields from the chained with debris in place area were similar to those from untreated areas.

Jockey's. The treated area showed significantly higher infiltration rates for all time intervals during simulated rainfall. In addition, and somewhat unexpectedly, significantly higher sediment was yielded from the treated area.

Indian Creek Conservation Area. In contrast to the Jockey's area, the untreated area shows significantly higher infiltration rates during the 5 to 6-minute time interval and all time intervals after 8 minutes of simulated rainfall. No significant differences in sediment yields were apparent between treated and untreated conditions.

CONCLUSIONS

Infiltration and sediment data collected with a Rocky Mountain infiltrometer on 14 sites in southern Utah indicate that areas cleared of pinyon-juniper trees and seeded to grass show no consistent decrease or increase in sediment yields or infiltration rates at a given point. Of 14 sites studied, four (all with debris windrowed) indicated decreased infiltration rates during one or more time intervals at points on the treated portion. Two sites indicated increased infiltration rates during one or more time intervals at points on the treated area. Eight sites showed no significant differences in infiltration rates between points for the treated and untreated conditions. As for sediment yields, one site had significantly less yield from points on the treated area and two sites had significantly higher sediment yields from points on the treated areas.

These findings are similar to the results recently reported from

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a study of 14 sites in central Utah (Williams, Gifford, and Coltharp, 1969). After study of 28 treated pinyon-juniper sites (of various age since treatment) throughout Utah (involving approximately 550 infiltrometer plots), it may be concluded that generally infiltration and erosion rates at a given point have not been particularly affected as a result of treatment practices. If there are treatment effects, they may be either positive or negative.

It is well known that many biotic, edaphic, and climatic variables interact to determine infiltration and erosion rates at a point on given landscapes. All of the above infiltrometer data are being further analyzed to determine those factors important in determining or predicting point infiltration rates and sediment yields on pinyon-juniper sites. Such analyses should aid in future predictions of the effect at a given point that certain vegetation conversion practices have on watershed parameters.

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Factors Influencing Infiltration and Erosion

on Chained Pinyon-Juniper Sites in Utah

Gerald Williams, Gerald F. Gifford, George B. Coltharp [1]

Defining those factors which influence infiltration rates is requisite to understanding hydrologic behavior of the 61.4 million acres (Dortignac, 1960) of pinyon-juniper in western United States. Many factors have been recognized as influencing infiltration, but studies of semi-arid wildland situations have been limited.

Williams, Gifford, and Coltharp (1969) and Gifford, Williams, and Coltharp (1970) have reported infiltration rate differences at random points between 28 chained and nearby unchained pinyon-juniper sites in central and southern Utah. Sediment yields were also measured. Results of the studies indicate that conversion of pinyon-juniper cover to grassland has not necessarily increased infiltration rates or always reduced sediment yields at a given point on such lands. Similar findings have resulted from small watershed studies in Arizona (Brown, 1970).

This study reports the influence of several vegetal and edaphic factors on infiltration and sediment production rates of pinyon-juniper (*Pinus monophylla-Juniperus osteosperma*) sites in Utah.

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Abstract. Relationships between vegetal and edaphic factors and infiltration rates and erosion as measured on 550 infiltrometer plots from pinyon and juniper sites in Utah were analyzed by multiple regression analysis. Those factors appearing most frequently in the equations for predicting infiltration rates (regardless of time interval) included total porosity in the 0-3 inch layer of soil, percent bare soil surface, soil texture in the 0-3 inch layer of soil, and crown cover. The ability to predict infiltration rates (as determined by R^2) varied with time and geographic location. Not only did R^2 vary, but independent variables explaining such variance also changed with time and location. Factors influencing sediment discharge were so variable from one geographic location to another that no consistent relation was found.

Methods

A Rocky Mountain infiltrometer (Dortignac, 1951) was utilized to simulate high intensity (three in/hr or greater) rainfall on plots approximately 2.5 ft^2 in size. Twenty-eight treated and 28 nearby untreated pinyon-juniper sites were sampled with a total of 550 infiltrometer plots near Price, Eureka, Milford and Blanding, Utah, during the summers of 1967 and 1968. Descriptions of the sites have been given previously (Williams, Gifford, and Coltharp, 1969; Gifford, Williams and Coltharp, 1970).

All plots were pre-wet a minimum of 2-3 hours before infiltrometer runs began. Runoff was measured at selected time intervals during each infiltrometer run. Simulated rainfall was applied to each plot until a constant runoff rate was reached.

Sediment was measured by collecting total runoff plus sediment from each plot, mixing thoroughly, and finally obtaining a 1-quart sample. The water was then evaporated off, sediment oven-dried, and sample weights converted to tons per acre.

Soil surface characteristics of each plot included percent bare surface soil, percent litter, percent rock (soil particles greater than two millimeters in diameter), and percent basal area of plants. These soil surface characteristics were measured with a point quadrat frame which covered an entire infiltrometer plot. The quadrat frame contained 100 points; therefore, each strike equalled 1 percent coverage.

Vegetal crown cover determinations were made in two ways. The first method utilized the point quadrat frame, and crown cover measurements were taken concurrently with soil surface characteristic measurements.

The second method consisted of clipping each plot. The total vegetal cover was bagged, then taken to the lab and oven dried for 24 hours. This oven dry weight (tons/acre) was used as an index of vegetal crown cover.

Percent rock $>$ 2mmd and soil texture were determined from disturbed soil samples collected from the top 3 inches of soil immediately adjacent to each plot or from the plot itself. Soil texture was determined by the hydrometer method (Bouyoucos, 1962).

Bulk density was determined from undisturbed samples taken from each plot with a Uhland soil sampler. Samples were returned to the laboratory and oven dried at 105 degrees centigrade for 24 hours.

The percentage of water stable sand-sized (0.02-2 millimeter diameter) soil aggregates in sieved soil samples was determined by using a modified Bouyoucos hydrometer method in which the Calgon was omitted.

Organic matter was determined by the loss on ignition method.

Soil porosity was measured on undisturbed soil samples prior to bulk density determinations. Porosity was determined at two moisture levels, one at oven dry conditions and the other at 30 cm tension. Measurements were made using a technique similar to that employed by Hoover, Olson, and Metz (1954).

Percent moisture of the surface soil of each plot was determined five minutes after an infiltrometer run was completed. The soil moisture by weight was determined by weighing the sample in wet condition, oven drying at 105 degrees C for 24 hours, then weighing again.

Analysis of Variables

An area-wise multiple regression analysis was utilized in analyzing infiltration-erosion relationships within and among the four major

geographic locations. Other independent variables besides those described under _Methods_ included site, treatment (untreated vs. treated) and total silt plus clay in the surface three inches of soil. The total number of independent variables was then increased to 40 (Table 1) by including squared and cubed values of those independent variables where preliminary graphing procedures indicated non linear relationships.

The five dependent variables were chosen to represent certain important aspects of natural high intensity convectional thunderstorms. Dependent variables included infiltration rate during the 3-4 minute time interval (this variable gives an indication of infiltration rates at the onset of a high intensity convectional storm), infiltration rate during the 8-13 minute time interval (this variable gives the infiltration rate perhaps midway through a typical convectional storm), infiltration rate during the 33-38 minute time interval (this time interval represents the final or constant infiltration rate), erosion in tons per acre per inch of runoff, and total water retained on a plot for 40 minutes (this variable gives the integrated retention capability of the soil).

Stepwise multiple regression equations were developed for each of the four chosen geographical areas in Utah: (1) East central part (Price area), (2) west central part (Eureka area), (3) southwest portion (Milford area), and (4) southeast portion (Blanding area). Figure 1 is a map showing location of infiltrometer studies. In addition, composite multiple regression equations were derived from all infiltrometer plots taken throughout the state.

Table 1. Variables related to infiltration and erosion that were measured on each infiltrometer plot

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Dependent Variables

Y_1 Infiltration rate (3-4 minute time interval)
Y_2 Infiltration rate (8-13 minute time interval)
Y_3 Final infiltration rate
Y_4 Erosion (tons per acre per inch of runoff)
Y_5 Total water retained on infiltrometer plots after 40 minutes

Independent Variables

X_1 Site (assigned a value from 1 to 28)
X_2 Treatment (untreated vs chained, and assigned a value of 1 and 2 respectively)
X_3 Organic matter (% in top 3 inches of soil)
X_4 Organic matter (%) squared
X_5 Organic matter (%) cubed
X_6 Bare soil (%)
X_7 Bare soil (%) squared
X_8 Crown cover (%) measured
X_9 Crown cover (%) squared
X_{10} Rock cover (%) $>$ 2 mm
X_{11} Rock cover (%) squared
X_{12} Litter cover (%)
X_{13} Litter cover (%) squared
X_{14} Plant bases (% area coverage)
X_{15} Plant bases (%) squared
X_{16} Soil moisture (% at 30 cm tension)
X_{17} Soil moisture (% at 30 cm tension) squared
X_{18} Soil moisture (% at 30 cm tension) cubed
X_{19} Total porosity (%)
X_{20} Total porosity (%) squared
X_{21} Total porosity (%) cubed
X_{22} Bulk density (gms/cc)
X_{23} Bulk density (gms/cc) squared
X_{24} Porosity at 30 cm tension
X_{25} Porosity at 30 cm tension squared
X_{26} Crown cover (dry wt., tons/acre)
X_{27} Crown cover (dry wt., tons/acre) squared
X_{28} Crown cover (dry wt., tons/acre) cubed
X_{29} Soil moisture (% in top 3 inches of soil 5 minutes after completion of infiltrometer run)
X_{30} Soil moisture (%) squared
X_{31} Soil (%) $<$ 2mm in 0-3 inch layer of soil

X32 Soil (%) squared
X33 Soil (%) cubed
X34 Soil sized aggregates (%) < 2mm in 0-3 inch layer of soil
X35 Soil sized aggregates (%) squared
X36 Rock (%) > 2 mm in 0-3 inch layer of soil
X37 Rock (%) squared
X38 Total silt plus clay (%) in 0-3 inch layer of soil
X39 Total silt plus clay (%) squared
X40 Total silt plus clay (%) cubed

Results and Discussion

Infiltration Rate During 3-4 Minute Time Interval. The multiple regression models presented below (Tables 2-6) include variables which each explained 1 percent or more of the variance associated with the given dependent variable in the original model which utilized 40 independent variables.

Price Area. At the Price area, 51 percent of the variability associated with infiltration rates during the 3-4 minute time interval was accounted for by utilizing 40 independent variables (Table 2). Of the 40 variables, only 12 explained 1 percent or more each of the variability. Six variables each accounted for two percent or more of the variability. Consideration of only the 12 variables explaining 1 percent or more of the variability associated with 3-4 minute infiltration rates yields an R^2 of .38.

The initial infiltration rates of a soil are frequently rather variable. This is understandable when factors influencing initial wetting, incipient ponding, and start of overland flow are considered. Timing of these events is not uniform from plot to plot and could be a contributing factor to variability associated with infiltration rates during the 3-4 minute time interval.

Eureka Area. The 40 variable multiple regression model accounted for 62 percent of the variability associated with infiltration rates during the 3-4 minute time interval within the Eureka area. Of the 40 independent variables, 15 explained 1 percent or more each of the variability while nine explained 2 percent or more each.

Uniformity of soil conditions in the Eureka area may account for the higher coefficient of determination. The authors noticed that sites within this geographic location contained few rocks over 2 mm in diameter in the top 3 inches of soil. This could be expressed in less erratic responses in magnitude of dependent variables to changes in magnitude of independent variables.

Blanding Area. Forty variables explained only 32 percent of variation associated with infiltration rates during the 3-4 minute time interval at the Blanding area. Eleven variables each accounted for 1 percent or more of the variation while only five accounted for 2 percent or more each.

Milford Area. Similar to the Blanding area, a rather low percentage of the variance in early infiltration rates was accounted for ($R^2 = .41$). Each of eight variables accounted for one percent or more of the variability while six accounted for 2 percent or more variability each.

Composite of all Areas. A model covering all four geographic locations accounted for 43 percent of the variability associated with infiltration rates during the 3-4 minute time interval. Eight variables accounted for 1 percent or more each of variability while only three explained 2 or more percent each.

Summary. The preceding five equations utilizing 40 dependent variables explained from 32 percent to 62 percent of the variance associated with infiltration rates during the 3-4 minute time increment. Of the 40 dependent variables, only treatment and sand sized water stable aggregates (between .02 and 2 millimeters in diameter) in the top three inches of soil (either singularly, squared, or cubed), failed to explain 1 percent or more of the variance in any of the multiple regression equations.

Figure 1. Map of Utah showing the four geographic locations which were studied (Price, Eureka, Blanding, and Milford, Utah).

It is possible that effects of sand sized aggregates are not apparent during the initial stages of an infiltration run. These effects become important when they are considered simultaneously with the rearrangement of soil particles into blocking larger pores. This phenomenon could become more important following a longer period of simulated rainfall.

The following four variables explained more than one percent of the variance in at least three out of five of the prediction equations: (1) total porosity (0-3 inches soil depth), (2) percent bare soil, (3) silt plus clay percent (0-3 inches depth), and (4) percent soil $<$ 2mmd, cubed (0-3 inches depth).

Infiltration Rate During the 8-13 Minute Time Interval

Price Area. The 40 variable model explained 62 percent of the variability associated with infiltration rates during the 8-13 minute time interval. Fourteen variables each explained 1 percent or more of the resultant variation, while each of seven accounted for 2 percent or more of the variation (Table 3).

Eureka Area. Sixty-five percent of the variance was explained by the 40 variables in the Eureka area. One percent or more of the variability was explained by each of 12 variables with seven explaining 2 percent or more each.

Blanding Area. The 40 variable model for Blanding yielded an R^2 = .59 with 14 variables each explaining one percent or more of the variance and five explaining 2 percent or more each.

Milford Area. The 40 variable multiple regression model explained 66 percent of the variance associated with infiltration rate during the

8-13 minute time interval. Thirteen independent variables each accounted for at least 1 percent of the variability while seven accounted for at least 2 percent each.

Composite of Four Areas. A surprising low percentage of variability associated with infiltration rates during the 8-13 minute time interval was explained using 40 variables. Forty-six percent was explained with six variables explaining 2 percent or more each of the variance while only seven accounted for 1 percent or more each of the variance.

Summary. The preceding five multiple regression model equations explained from 46 to 66 percent of variation associated with the 8-13 minute infiltration rate.

Percent bare soil surface squared accounted for 1 percent or more of the variation in four of the five equations for this particular time interval. Crown cover (percent), percent rock (0-3 inches), total porosity, and soil moisture percent (5 minutes following infiltrometer run) each explained 1 percent or more of variability in three out of five multiple regression model equations.

The importance of these variables to infiltration rates is understandable. Effects of crown cover and/or bare soil may become of increasing importance as the time from the beginning of an infiltrometer run is increased. Percent rock in the surface 3 inches of soil and total porosity manifest an influence on soil moisture primarily through their effects on permeability and hydraulic conductivity in the subsoil. Conceivably these factors would show an importance once the soil surface is wetted and moisture begins percolating through subsurface soils.

Composite of all Areas. Only 46 percent of the variability was explained in the 40 variable model utilizing 550 plots from all areas combined. Ten variables accounted for 1 percent or more each of the variability while each of four explained 2 percent or more.

Summary. The preceding multiple regression models, developed for predicting infiltration rates for the 33-38 minute time interval of an infiltration run, explained from 45 to 70 percent of the variability associated with infiltration rates measured during this time interval. Of the 40 independent variables used to develop these models only two explained 1 percent or more of the variability in three or more model questions. Crown cover (tons per acre) explained 1 percent or more of the variability in three out of five model equations and crown cover (tons per acre) squared explained 1 percent or more variability in four of the five equations. Again, this relationship can be attributed to the protection against raindrop impact afforded by crown cover. As one progresses further into an infiltration run, the duration of applied rainfall increases, thus giving a greater opportunity for destruction of soil surface features which normally promote infiltration. Surface runoff and infiltration together transport smaller particles into larger pores, thereby creating conditions capable of impeding infiltration rates.

The only variable (either singularly or squared) which did not explain 1 percent or more of the variability in any of the five regression equations was percent basal area.

Erosion-Tons per Acre per Inch of Runoff. This parameter was measured for each of the four areas and a composite of the four areas.

Price Area. For the Price area only 33 percent of the variability associated with erosion in tons per acre per inch of runoff was explained using a 40 variable multiple regression analysis (Table 5). Each of twelve variables accounted for 1 percent or more of the variability and four explained at least 2 percent each.

Eureka Area. A substantially higher percentage of variability was explained in the 40 variable model in the Eureka area for erosion in tons per acre per inch of runoff. Sixty-three percent of the variability was explained with each of eight variables explaining 1 percent or more of the variance and seven accounting for 2 percent or more each.

Blanding Area. Forty-nine percent of the variability associated with this dependent variable was explained in the 40 variable regression model. Of the 40 variables, 1 percent or more of the variation was explained by each of 13 variables and 2 percent or more was explained by each of 10 variables.

Milford Area. Again very little of the variability associated with erosion rates in tons per acre per inch of runoff was explained in the multiple regression model. Thirty-four percent of the variability was explained using 40 variables, with seven independent variables accounting for 1 percent or more each of this variability and only two variables explaining 2 percent or more each.

Composite of all Areas. Only 29 percent of variability associated with erosion was explained with a 40 variable model. A model of this nature could not be successfully utilized for predicting erosion. Only five

variables accounted for more than 1 percent each of the variability, and only three variables accounted for 2 percent or more each.

Summary. Utilizing five multiple regression equations, 29 to 63 percent of variability associated with erosion in tons per acre per inch of runoff was explained. Of the five equations, only the one developed for the Eureka area explained more than 49 percent of the variation associated with erosion. Equations developed for Price, Milford, and a composite of all areas explained 34 percent or less of the measured variability.

Such results indicate the extreme complexities in factors affecting erosion. Interactions among factors or lack of measurement of contributing factors could be a cause for such low explained percentages.

Bulk density and site were the only two variables that appeared in three or more multiple regression equations. The fact that site exerts an influence indicates that certain unmeasured site conditions are contributing to unexplained variability.

It is unusual that no variables pertaining to crown cover (either percent coverage or tons per acre) or aggregate stability explained 1 percent or more of the variability in any of the equations. It is possible that aggregates greater than 2 mm diameter are of more importance than aggregates less than 2 mm diameter for predicting erosion losses. There is also the possibility that stability of soil aggregates is a function of season of sampling, as shown by Bisal and Ferguson (1968).

Equations developed for predicting erosion generally indicate that most of the 40 factors should be supplemented with other site factors before a successful prediction model can be developed.

Total Water (Inches) Retained on Each Infiltrometer Plot After 40 Minutes.

Price Area. Sixty-five percent of the variability associated with total water retained on each plot was explained utilizing 40 variables at the Price area (Table 6). Fourteen variables explained at least 1 percent of this variability with seven variables explaining 2 percent or more.

Eureka Area. The multiple regression model explained 60 percent of the variability associated with this particular hydrologic parameter. Thirteen variables explained at least 1 percent each of the variability while six accounted for at least 2 percent each.

Blanding Area. Only 47 percent of the variability in total water retained on each infiltrometer plot after 40 minutes was accounted for by 40 variables in the Blanding area. Of this variability 1 percent or more was accounted for by each of 11 variables, and 2 percent or more was explained by each of four variables.

Milford Area. Sixty-nine percent of the variability in total water retained was accounted for utilizing the 40 variable equation at the Milford area. Thirteen variables each accounted for 1 percent or more of the variability while nine explained 2 percent or more.

Composite of all Areas. Fifty percent of the variability associated with total water retained on each plot was explained in the 40 variable model. Two percent or more of this variability was explained by each of five variables and 1 percent or more was explained by each of 10 variables.

Summary. The preceding five multiple regression equations explained from 47 to 69 percent of the variability associated with total water retained on a plot during a 40 minute infiltrometer run. Of the 40 variables used,

a plot during a 40 minute infiltrometer run. Of the 40 variables used, only two did not explain (either singularly, squared, or cubed) 1 percent or more of the variability in at least one of the model equations. The two are bulk density and percent basal area coverage. Crown coverage in tons per acre accounted for 1 percent or more of the variability in all five equations and this same variable squared appeared in four out of five equations. Micro-porosity (pores retaining water at 30 cm tension) and macro-porosity (porosity at 30 cm tension) explained at least 1 percent of the variability in three out of five equations.

The relative importance of these variables is understandable. The importance of crown cover has previously been discussed. The fact that crown cover in tons per acre appears in all five of the multiple regression equations for total water retained on each plot substantiates evidence indicating its increasing importance as one progresses further into an infiltration run. Percent soil moisture 5 minutes following an infiltrometer run also appeared in four out of five prediction equations. The retention of soil moisture after 5 minutes of drainage is related to infiltration phenomena as it is influenced by hydraulic conductivity of the soil sample. Micro and total porosity influence the amount of water retained on each plot through their effect on subsurface water movement.

Conclusions

Studies of factors influencing infiltration and erosion on 28 chained pinyon-juniper sites throughout central and southern Utah have shown that geographic location, time of the event, and the parameter of interest (infiltration rate, erosion, or total water retained on plot) are important considerations in such determinations.

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Table 7 shows percent variance in infiltration rates, total water retained, and sediment production explained by 40 variable multiple regression equations during different time periods within an infiltrometer run. Within a given time period the explained variance in infiltration rates may vary considerably with geographic location (3-4 minute and 33-38 minute time intervals). At other times (8-13 minute time interval) the response among locations may be rather uniform.

Explained variance associated with infiltration rates at a given location is not uniform among varying time intervals.

Lumping all geographic locations together generally tends to minimize effectiveness of the predictive equations, regardless of the dependent variable.

Not only does the ability to explain variance associated with infiltration change with time and geographic location, but the parameters explaining such variance also change with time and location. This is shown in that 8 to 12 variables, 7 to 14 variables, and 9 to 12 variables explained more than one percent variance in infiltration rates during the 3-4 minute, 8-13 minute and 33-38 minute time intervals, respectively. Such variation was also shown in predicting total sediment discharge and to a lesser extent in predicting total water retained on the plots. Those variables appearing in most of the equations for predicting infiltration rates during a given time period were similar for the 3-4 minute and 8-13 minute time intervals, but changed completely for the 33-38 minute infiltration rate. Important variables influencing total water retained on the plots were similar to factors influencing infiltration rates during the 33-38 minute time interval. Those factors appearing most frequently

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in the equations for predicting infiltration rates (regardless of time interval) include total porosity in the 0-3 inch layer of soil, percent bare soil surface, soil texture in the 0-3 inch layer of soil, and crown cover. Percent bare soil may be particularly important on many of our semi arid rangeland watersheds, especially as related to annual runoff values (Lusby, 1970; Branson and Owen, 1970).

Factors influencing sediment discharge in this study were so variable from one geographic location to another that no consistent relation was found. This finding was similar to studies in the big sagebrush (*Artemisia tridentata*) type in Nevada (Gifford and Skau, 1967). Much additional work is needed in this field of study.

Based on the above, it is important that range and forest hydrologists working in the pinyon-juniper and other vegetation types recognize the complexity which exists in relation to hydrologic phenomenon. Though limitations exist on small plot estimates of infiltration (Hickok and Osborn, 1969), this study indicates that guidelines prepared for hydrologic analysis on pinyon-juniper sites similar to those sampled in this study should take into consideration the geographic area, the parameter of interest, and where applicable, the timing of an event.

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Table 2. Multiple regression equations [1/] for predicting infiltration rate (Y_1) during the 3-4 minute time interval.

Price Area

$$Y_1 = 1.40 - 0.017X_{28} - 0.009X_{15} + 0.12X_{14} + 0.021X_{19} - 0.001X_{25} + 0.025X_5 + 1.68X_3 - 0.40X_4 - 0.014X_6 + 0.0005X_{32} - 0.054X_{23} + 0.021X_{33}$$

$R^2 = .38$ (Inclusion of 40 variables gives $R^2 = .51$)

Eureka Area

$$Y_1 = 2.77 + 0.016X_4 - 0.019X_{36} - 0.002X_9 - 0.004X_{39} + 0.00003X_{40} - 0.00007X_{33} + 0.083X_8 + 0.0005X_{30} - 0.0007X_{20} + 0.22X_{31} + 0.001X_7 + 0.63X_{10} - 0.10X_6 + 0.16X_1 + 0.072X_{12}$$

$R^2 = .58$ (Inclusion of 40 variables gives $R^2 = .62$)

Blanding Area

$$Y_1 = 1.25 - 0.011X_3 - 0.031X_{10} + 0.14X_{29} - 0.003X_{30} - 0.00001X_{18} + 0.002X_{17} - 0.096X_2 + 0.001X_{25} - 0.0002X_{39} + 0.000007X_{33} + 0.081X_{38}$$

$R^2 = .14$ (Inclusion of 40 variables gives $R^2 = .32$)

Table 2. Continued

Milford Area

$$Y_1 = 4.68 + 0.10X_{31} - 0.023X_{19} + 0.00008X_{20} + 0.012X_{12} - 0.020X_{27} - 0.004X_{32} + 0.00003X_{33} - 0.016X_6$$

$R^2 = .27$ (Inclusion of 40 variables gives $R^2 = .41$)

Composite of all Areas

$$Y_1 = 4.88 + 0.038X_1 - 0.043X_6 + 0.0003X_7 - 0.0096X_{19} + 0.44X_{26} - 0.020X_{36} - 0.006X_{38} - 0.0000006X_{40}$$

$R^2 = .33$ (Inclusion of 40 variables gives $R^2 = .43$)

1/ Each independent variable explained 1 percent or more of the variance associated with Y_1 in the original model which utilized 40 variables. See Table 1 for a listing of variables.

Table 3. Multiple regression equations 1/ for predicting infiltration rate (Y_2) during the 8-13 minute time interval.

<u>Price Area</u>

$$Y_2 = 3.94 - 0.01X_{34} + 0.0009X_9 + 0.00006X_{20} - 0.00003X_7 - 0.009X_{15} + 0.10X_{24} - 0.004X_{25} + 0.003X_{10}$$
$$+ 0.011X_{29} - 0.001X_5 + 0.037X_3 + 0.064X_{14} + 0.068X_{31} + 0.0004X_{39}$$

R^2 = .45 (Inclusion of 40 variables gives R^2 = .62)

<u>Eureka Area</u>

$$Y_2 = 1.2 - 0.0001X_{20} - 0.001X_8 - 0.00002X_{33} - 0.23X_{29} + 0.00006X_7 + 0.31X_{26} - 0.13X_6 + 0.0009X_{30}$$
$$+ 0.51X_{22} + 0.0004X_{35} + 0.002X_{32} + 0.0005X_{13}$$

R^2 = .52 (Inclusion of 40 variables gives R^2 = .65)

<u>Blanding Area</u>

$$Y_2 = 7.61 - 0.032X_{34} - 0.010X_{29} + 0.000003X_7 + 0.007X_{19} + 0.00001X_{21} - 0.004X_{16} - 0.00005X_{39} - 0.001X_{20}$$
$$+ 0.0005X_{36} + 0.006X_{35} - 0.48X_{26} + 1.59X_{27} - 0.048X_{10} - 0.14X_1$$

R^2 = .37 (Inclusion of 40 variables gives R^2 = .59)

Table 3. Continued

<u>Milford Area</u>

$$Y_2 = 9.19 - 0.0002X_{13} - 0.00005X_{40} - 0.009X_{19} - 0.000007X_{30} - 0.013X_{27} + 0.008X_{39} - 0.40X_{38} + 0.001X_{37}$$
$$+ 0.002X_{11} + 0.064X_{16} - 0.10X_{36} + 0.039X_8 + 0.050X_{12}$$

R^2 = .56 (Inclusion of 40 variables gives R^2 = .66)

<u>Composite of all Areas</u>

$$Y_2 = 3.17 + 0.019X_1 - 0.000003X_7 + 0.014X_8 + 0.016X_{12} - 0.015X_{36} - 0.034X_{38} + 0.000001X_{40}$$

R^2 = .34 (Inclusion of 40 variables gives R^2 = .46)

1/ Each independent variable explained 1 percent or more of the variance associated with Y_2 in the original model which utilized 40 variables. See Table 1 for a listing of variables.

Table 4. Multiple regression equations 1/ for predicting infiltration rate (Y_3) during the 33-38 minute time interval.

Price Area

$$Y_3 = 4.00 - 0.0001X_{13} + 0.007X_{34} + 0.00009X_7 + 0.024X_{12} + 0.071X_{23} + 0.050X_{28} + 0.00031X_{11} + 0.000007X_{20} + 0.0008X_9 + 0.00003X_{30} - 0.0005X_{31} + 0.0003X_{32}$$

$R^2 = .42$ (Inclusion of 40 variables gives $R^2 = .68$)

Eureka Area

$$Y_3 = 1.99 + 0.003X_{24} - 0.00003X_{33} + 0.24X_{26} + 0.38X_2 + 0.0004X_5 - 0.006X_{10} - 0.001X_6 + 0.0004X_{35} + 0.63X_{22} + 0.002X_{32} + 0.020X_{12}$$

$R^2 = .29$ (Inclusion of 40 variables gives $R^2 = .47$)

Blanding Area

$$Y_3 = 4.47 - 0.00004X_{37} - 0.00008X_{35} - 0.005X_{16} - 2.18X_{26} - 6.72X_{28} + 9.07X_{27} + 0.002X_{11} - 0.086X_{10} - 0.090X_1$$

$R^2 = .35$ (Inclusion of 40 variables gives $R^2 = .45$)

Table 4. Continued

Milford Area

$$Y_3 = 10.40 - 0.00005X_{40} + 0.001X_{17} - 0.010X_{19} - 0.0001X_{20} + 0.0009X_{37} + 0.009X_{39} - 0.43X_{38} - 0.084X_{36}$$
$$- 1.10X_{27} + 3.02X_{26} + 0.26X_{12}$$

$R^2 = .60$ (Inclusion of 40 variables gives $R^2 = .70$)

Composite of all Areas

$$Y_3 = 7.51 + 0.01X_1 - 0.003X_4 - 0.00001X_7 + 0.015X_{12} + 0.94X_{26} - 0.39X_{27} - 0.012X_{36} - 0.30X_{38}$$
$$+ 0.005X_{39} - 0.00003X_{40}$$

$R^2 = .36$ (Inclusion of 40 variables gives $R^2 = .46$)

1/ Each independent variable explained 1 percent or more of the variance associated with Y_3 in the original model which utilized 40 variables. See Table 1 for a listing of variables.

Table 5. Multiple regression equations [1/] for predicting erosion in tons per acre per inch of runoff (Y_4)

Price Area

$$Y_4 = 9.61 - 0.039X_6 + 0.0004X_7 + 0.033X_{12} - 0.0001X_{39} - 0.002X_{32} - 0.0003X_{25} + 0.000004X_{21} - 0.00001X_{18}$$
$$+ 2.85X_{23} - 9.38X_{22} - 0.0005X_{13}$$

$R^2 = .18$ (Inclusion of 40 variables gives $R^2 = .33$)

Eureka Area

$$Y_4 = 9.12 + 0.32X_2 - 0.88X_{22} + 0.13X_4 - 0.41X_{19} - 0.021X_5 + 0.005X_{20} - 0.002X_{39} + 0.069X_{29}$$

$R^2 = .57$ (Inclusion of 40 variables gives $R^2 = .63$)

Blanding Area

$$Y_4 = 1.03 - 0.047X_4 + 0.0004X_2 + 0.000003X_{40} + 0.48X_3 - 0.083X_1 + 0.000003X_{33} + 0.002X_{11} - 0.003X_{20}$$
$$- 0.00004X_{18} - 0.29X_{16} + 0.007X_{25} - 0.72X_{24} + 0.59X_{19}$$

$R^2 = .32$ (Inclusion of 40 variables gives $R^2 = .49$)

Milford Area

$$Y_4 = 1.59 + 0.028X_{14} - 0.023X_1 - 0.16X_{23} + 0.0002X_{17} - 0.019X_{29} + 0.0000006X_{33} + 0.0004X_{30}$$

$R^2 = .23$ (Inclusion of 40 variables gives $R^2 = .34$)

Table 5. Continued

Composite of all Areas

$$Y_4 = 2.36 - 0.018X_1 - 0.0001X_{13} + 0.00001X_{18} - 1.04X_{22} + 0.0002X_{30}$$

$R^2 = .22$ (Inclusion of 40 variables gives $R^2 = .29$)

1/ Each independent variable explained 1 percent or more of the variance associated with Y_4 in the original model which utilized 40 variables. See Table 1 for a listing of variables

Table 6. Multiple regression equations 1/ for predicting total water retained (inches) on infiltrometer plots after 40 minutes.

Price Area

$$Y_5 = 7.4 - 0.031X_2 + 0.079X_3 + 0.001X_{16} - 0.014X_4 - 0.015X_{24} + 0.005X_9 + 0.55X_{28} - 1.39X_{27} + 0.00009X_{11} + 0.94X_{26} + 0.0001X_{20} + 0.00006X_{30} + 0.023X_{31} + 0.0001X_{39}$$

$R^2 = .43$ (Inclusion of 40 variables gives $R^2 = .65$)

Eureka Area

$$Y_5 = 1.6 + 0.18X_{26} + 0.0004X_{39} - 0.00002X_{33} - 0.0002X_9 + 0.0007X_8 + 0.002X_{10} - 0.004X_6 + 0.0003X_{30} - 0.0002X_{20} + 0.0002X_{35} + 0.037X_1 + 0.001X_{32} + 0.0004X_{13}$$

$R^2 = .56$ (Inclusion of 40 variables gives $R^2 = .69$)

Blanding Area

$$Y_5 = 3.09 - 0.00009X_{30} - 0.012X_4 - 0.0000007X_{21} - 0.0008X_{16} - 1.71X_{26} - 5.07X_{28} + 0.0003X_{35} - 0.02X_{10} + 6.94X_{27} + 0.0001X_{37} - 0.05X_1$$

$R^2 = .33$ (Inclusion of 40 variables gives $R^2 = .47$)

Table 6. Continued

Milford Area

$$Y_5 = 5.65 - 0.00003X_{40} + 0.0005X_{37} + 0.004X_{39} - 0.23X_{38} - 0.012X_{19} - 0.00001X_{30} + 0.00004X_{20} + 0.03X_{16} + 0.00008X_{11} - 0.048X_{36} - 0.70X_{27} + 2.03X_{26} + 0.018X_{12}$$

$R^2 = .60$ (Inclusion of 40 variables gives $R^2 = .69$)

Composite of all Areas

$$Y_5 = 2.73 + 0.008X_1 - 0.17X_6 + 0.0001X_7 + 0.007X_{12} - 0.00008X_{17} + 0.70X_{26} - 0.29X_{27} - 0.008X_{36} - 0.022X_{38} + 0.0000009X_{40}$$

$R^2 = .40$ (Inclusion of 40 variables gives $R^2 = .50$)

1/ Each independent variable explained 1 percent or more of the variance associated with Y_5 in the original model which utilized 40 variables. See Table 1 for a listing of variables.

Table 7. Percent variance (R^2 x 100) in infiltration rates (in./hr.), total water retained on infiltrometer plots, and sediment production explained by 40 variable multiple regression equations.

Geographic Location	Infiltration rate time interval 3-4 min.	8-13 min.	33-38 min.	Total water Retained on Plots (inches)	Sediment Production (tons/acre/inch of runoff)
Price Area	51	62	68	65	33
Eureka Area	62	65	47	69	63
Blanding Area	32	59	45	47	49
Milford Area	41	66	70	69	34
Composite	43	46	46	50	29

Some Water Movement Patterns Over And Through Pinyon-juniper Litter 1/

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Highlight

Fluorescent dye patterns depicting water movement over and through pinyon-juniper litter accumulations varied somewhat according to canopy density of the trees. Where the canopy was closed, or nearly so, the dye was confined to the surface 1 inch of litter, with no lateral movement indicated. Where the tree canopy was broken or open, dye was found to a maximum depth of 6 inches beneath the litter and lateral downhill movement of at least 25 inches was indicated on the litter surface. Where dye had penetrated the litter, both a streaked and a uniform (even wetting front) pattern of water movement were observed.

Introduction

Patterns of water movement in natural plant communities have been of interest for many years. Such patterns may exist due to unique spatial and temporal characteristics of rainfall, because of characteristics of the flora which influence interception, transpiration, etc., and/or because of soil characteristics peculiar to a given site.

Importance of liter as a hydrologic factor in the pinyon-juniper (P-J) type has been noted by Scholl (1969). He found that resistance to wetting in the surface soils of a P-J watershed near Flagstaff, Arizona, increased from completely wettable in open areas to highly nonwettable in the litter under the juniper canopy. Similar findings have occurred in other vegetation types. Apparently organic unknowns which accumulate from litter decomposition or fungal activity cause the wettability problems.

The purpose of this study was to study patterns of water movement over and through pinyon-juniper leaf litter.

Methods

Water movement was traced on a pinyon-juniper (*Pinus monophylla*, *P. edulis*--*Juniperus osteosperma*)site in Southeastern Utah (45 miles west of Blanding, Utah) through use of two water soluble fluorescent dyes, Pyranine 1/ and Kiton Yellow 2/. Pyranine will fluoresce in damp soil and Kiton Yellow fluoresces in the dry state.

During mid-June of 1969, 27 bands of dye powder (1 part Kiton Yellow to 1 part Pyranine) about 3 inches wide were put on the litter covered interspaced between suitable pinyon-juniper trees (Figure 1). The dyes

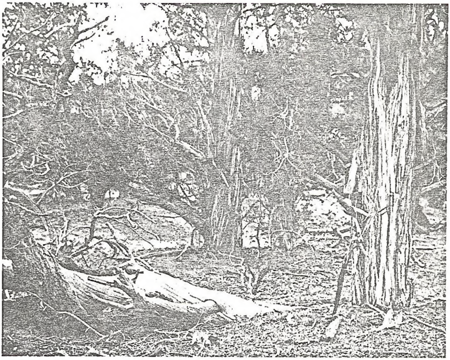

Figure 1. Litter accumulation beneath two adjacent juniper trees. A band of dye powder would run from the base of one tree to the base of the other.

were applied from a salt shaker at a rate of about 200 g/m2, as recommended by Reynolds (1966). The dye transects varied from 48 to 170 inches in length and each ran from the base of one tree to the base of a nearby adjacent one. Maximum depth of litter was approximately 2.5 inches, with an average of about 1.5 inches.

In early September trenches were excavated along 20 randomly selected bands to study vertical dye penetration patterns. The remaining 7 bands were used to study water movement patterns over the litter surface. All measurements were made at night using a battery powered UVL-21 ultra-violet lamp.

Results

Penetration of dye into the litter was variable and type of pattern appeared related to tree canopy density. Where canopies were closed, or nearly so, the dye was confined to the surface 1 inch of litter with no lateral movement indicated. Since total rainfall during the study period measured only 3.80 inches, throughfall and foliage drip was probably minimal under the closed canopies.

Where canopies were somewhat broken, dye patterns indicated rather nonhomogeneous vertical water movement, as shown in Figure 2. Similar irregular drainage patterns in woodland environments have been shown by Voigt (1960), Rutter (1964) and Reynolds (1966). Little or no dye movement was indicated next to either pinyon or juniper tree trunks, indicating that perhaps stemflow is rather insignificant in this type. Maximum depth of dye penetration beneath the litter surface along any excavated transect was 6 inches.

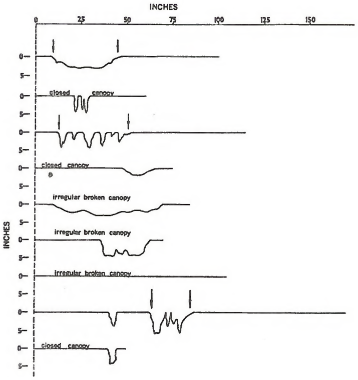

Figure 2. Examples of some vertical dye penetration patterns through P-J litter. Arrows indicate that portion of dye band over which the canopy was open.

Some lateral flow over the litter surface also occurred where canopies were broken or open. Maximum indicated distance of overland flow was 25 inches, with vertical penetration into the litter of 1 inch or less. There were no indications of lateral flow within the litter cover. The overland flow may result when litter accumulations become dry and unwettable.

Conclusions

The influence of litter on hydrologic behavior of natural plant communities is not well defined. This study has shown that patterns of water movement upon and through pinyon-juniper litter are variable and are somewhat related to tree canopy density. Where the canopy is open, water may move uniformly through the litter or along pathways which result in a streaked dye pattern. Where water cannot penetrate the litter, then overland flow may occur for at least short distances.

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